



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/IL96/00074</p> <p>(22) International Filing Date: 7 August 1996 (07.08.96)</p> <p>(30) Priority Data: 08/514,050 11 August 1995 (11.08.95) US</p> <p>(71) Applicant (for all designated States except US): RAMOT UNIVERSITY AUTHORITY FOR APPLIED RESEARCH &amp; INDUSTRIAL DEVELOPMENT LTD. [IL/IL]; P.O. Box 39296, 61392 Tel Aviv (IL).</p> <p>(72) Inventors; and (75) Inventors/Applicants (for US only): GOVER, Avi [IL/IL]; 19 Hamachtenet Street, 47203 Ramat Hasharon (IL). KASTNER, Raphael [IL/IL]; 9 Zamir Street, 45100 Hod Hasharon (IL).</p> <p>(74) Agent: FRIEDMAN, Mark, M.; Samueloff Building, 7 Haomanim Street, 67897 Tel Aviv (IL).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>Without international search report and to be republished upon receipt of that report.</i></p>
<p>(54) Title: HIGH ALTITUDE CELLULAR COMMUNICATION SYSTEM PLATFORM</p> <p>(57) Abstract</p> <p>A high altitude cellular communications system platform utilizing a multi-beam array antenna having an array of elements. A multi-beam array antenna and associated circuitry are mounted on a high altitude atmospheric/stratospheric platform positioned up to 150 kilometers high. A cellular communications processor controls setup and tear down of wireless communication links or calls with subscriber's personal communication devices. Vertical broadcasting provides sharp antenna radiation pattern boundaries between cells allowing for both high inter-cell resolution and small cell size. In an alternative embodiment, the cellular communications processor is located on the ground and communicates with the high altitude platform via a communications link. The system can operate independently or in conjunction with ground based cellular systems and Low Earth Orbit Satellite systems using common personal communication devices.</p>		

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## HIGH ALTITUDE CELLULAR COMMUNICATION SYSTEM PLATFORM

### FIELD AND BACKGROUND OF THE INVENTION

Today, the demand for wireless cellular communications, including  
5 personal communication services (PCS), is growing at a faster and faster  
rate. United States PCS usage alone is currently estimated at 31 million  
subscribers by the year 2003 and 150 million in the long run. The PCS  
international industry is expected to be worth 195 billion dollars by the end  
of the decade. High demand currently exists for both narrowband  
10 communications (i.e. voice, picture phone, paging and private radio) and  
wideband communications (i.e. video, multimedia and high bandwidth  
digital data). A limited frequency band, however, has been allocated to  
cellular communication. In the United States, the Federal Communications  
Commission (FCC) has recently allocated at present 3 MHz centered  
15 around 900 MHz for narrowband communications and 120 MHz centered  
around 2 GHz for wideband communications.

Without cellular technology, a very limited number of calls could  
take place simultaneously in the same region. Cellular technology greatly  
expands the number of calls that can simultaneously be made. Regions  
20 with high demand for cellular telephone subscriptions are broken down  
geographically into smaller sized cells. A large city or densely populated  
region may be divided into a large number of cells. Each cell has a base  
station and is able to support a finite number of simultaneous calls. Base  
stations include transmission and receiving equipment for communicating  
25 with subscriber cellular equipment, such as telephones. Each base station  
maintains communication links with all other cells as well as maintaining  
access to the standard telephone network. Both base station transmitters  
and cellular communication devices transmit radio signals at a reduced  
power level. Transmitted power is reduced in order to ensure that  
30 communications taking place in one cell do not interfere with

communications in other cells. It is this feature of cellular communications that makes it possible to reuse the limited frequency spectrum available in cells that are remote enough to avoid interference and crosstalk between them.

5       The limitation of conventional cellular communication systems is that it is very difficult to limit the range of the base station radio transmitters and at the same time maintain a uniform level of radio transmission and reception within the cell, a necessary condition for maintaining reliable communications. Radio waves emitted from the  
10 antennas of base station transmitters decay gradually, typically at a rate of  $1/R^4$ ,  $R$  being the distance from the base station antennas, and do not maintain a uniform level within the cell. In addition, due to destructive scattering, reflections and wave interference (especially in areas with numerous structures) the radio signal level at each point in the cell is  
15 unpredictable and is susceptible to periodic fading and statistical variation. The situation becomes worse when considering hand held personal cellular or motor vehicle cellular communications, both of which are mobile. As the cells become smaller, this problem becomes more and more acute. This is due to the larger affect of statistical variation of the communication  
20 range. This is a major obstacle for increasing the volume of cellular communication service. With present day technology, often the entire available frequency spectrum has been used. The only way to increase the service volume is by reducing the size of the cells.

      The difficulty in maintaining both a uniform broadcasting level  
25 within the cell and a sharp cutoff beyond the cell boundary, results in problematic and poor quality cellular communications. Due to the lack of a sharp cutoff in the power level across cell boundaries, the reuse rate of the spectral bandwidth is reduced. Typically, the reuse rate in a hexagonal lattice cell arrangement is less than 1:7. This means that each cell, in a  
30 group of seven neighboring cells, must use different portions of the

available spectrum. Spectral band reuse can only take place in the adjacent group of seven cells. Crosstalk, however, still occurs, reducing the quality of the communications.

Another disadvantage of conventional cellular technology is that due to the need to maintain a minimum power level at cell boundaries, destructive wave interference sites and areas shadowed by building structures, the power of the base station transmitter must be high. In densely populated areas high transmitted power is a common source of concern with residents residing near the base station apprehensive about radiation hazards.

In addition, in order to maintain radio communication with subscribers at any geographical point in the cell at all times, the power of the subscriber's radio transmitter must be higher than essentially required. This is due to nonuniformity within the cell of the reception sensitivity of the base station receiver. This nonuniformity is similar in nature to the transmission nonuniformity described above. Reception sensitivity nonuniformity and the consequent need to increase the power of the subscriber's radio transmitter causes personalized cellular communications devices to be heavier and more expensive than necessary, in addition to generating complaints from radiation hazard conscious subscribers.

#### SUMMARY OF THE INVENTION

The present invention overcomes the disadvantages and limitations of the prior art by providing a system of cellular communications employed at high altitude on a floating, flying or hovering platform that utilizes multi-beam array antenna technology. The platform consolidates many conventional base stations into one system, eliminating the need for redundant equipment.

A main advantage of utilizing a multi-beam array antenna, mounted on a high altitude platform, is that the array can be designed to have

radiation lobes (i.e. beams) with sharp boundaries between cells. The ground can, therefore, be illuminated by a beam with a slowly varying distribution, greatly reducing the effects of diffractions from obstacles, multiple scattering and rapid variations and fading of the signal. This  
5 advantage is due mostly to the effects of communicating in the vertical direction, rather than in the horizontal direction. An added benefit is that in military applications, vertical communication provides better electronic intelligence (ELINT) security and better immunity to jamming and other types of electronic warfare.

10 In addition, the shape of each individual beam can be optimized, using aperture synthesis techniques, to increase insulation and reduce crosstalk between cells. This allows both the base station transmitter and the personal communications devices, to transmit and receive power at a reduced level resulting in lighter weight portable radio devices, longer  
15 battery life, lower cost, less health risk from radiation hazards, etc. The more efficient upwards looking antennas included in personal communication devices of such a system further reduce the required transmit power resulting in the same benefits in connection with reduced transmit power levels.

20 The boundaries for the entire service area can be easily changed by transporting the high altitude platform to a new location. This mobility also allows cellular service to be setup quickly to provide coverage for new service areas, on a temporary basis over disaster areas (e.g., earthquakes, floods, fires or other events leading to outage of ground  
25 based communication or requiring major evacuation), special events and for military applications.

Use of multi-beam array antenna technology allows cells to be reassigned dynamically. Cell coverage (e.g., cell size reduction and expansion) can be electronically controlled and adjusted in response to, for  
30 example, changes in communication load distribution, emergencies, etc.

In addition, reliability and stability are increased and the area of service coverage expanded by connecting, either physically or electronically, two or more floating platforms controlled by a central computer.

5       Hence, there is provided according to the teachings of the present invention, a high altitude platform cellular communications system comprising a cellular communications processor for controlling a plurality of wireless radio communication links between a plurality of cellular communication devices and the system, multi-beam array antenna control  
10 circuitry coupled to the cellular communications processor, the multi-beam array antenna control circuitry for controlling radio frequency transmission from and reception to the high altitude cellular communications system, multi-beam array circuitry coupled to the multi-beam array antenna control circuitry, the multi-beam array circuitry for simultaneously generating a  
15 plurality of transmission signals and for simultaneously receiving a plurality of reception signals, a multi-beam array antenna coupled to the multi-beam array circuitry, the multi-beam array antenna for simultaneously generating a plurality of independent beams for transmission and reception of radio signals to and from assigned terrestrial  
20 cells, and a high altitude platform for supporting the high altitude cellular communications system at a predetermined altitude, the high altitude platform for approximately maintaining the position of the high altitude cellular communications system at the predetermined altitude and horizontal position.

25       While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawing, wherein:

FIG. 1 is a block diagram of a preferred embodiment of the present invention illustrating an airborne based cellular communications processor; and

FIG. 2 is a block diagram of a preferred embodiment of the present invention illustrating a ground based cellular communications processor.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

10 The present invention is of a cellular communications system mounted on a high altitude platform and utilizing a multi-beam array antenna to broadcast a multitude of signals simultaneously to cells located on the ground.

The principles and operation of the present invention may be better 15 understood with reference to the drawing and the accompanying description.

A block diagram of an embodiment of the present invention is shown in Figure 1. This embodiment includes an airborne based cellular communications processor 26 at the core of cellular communications 20 system 10. Coupled to airborne cellular processor 26 is multi-beam array (MBA) antenna control circuitry 30. Coupled to MBA antenna control circuitry 30 is multi-beam array (MBA) radio frequency (RF) antenna circuitry 24. Coupled to MBA RF antenna circuitry 24 is an MBA antenna 14. MBA antenna 14 includes a plurality of array elements 16. 25 The entire system is mounted on a high altitude platform 12 that can either float, hover or fly over a certain area on the ground. Platform 12 may be a blimp, drone, airplane, remotely piloted vehicle (RPV), helicopter or the apparatus for supporting an unmanned airborne vehicle disclosed in U.S. Patent No. 5,074,489, issued to Gamzon, entitled Method And System For



Supporting An Airborne Vehicle In Space. A preferred embodiment includes high altitude platform 12 disclosed in U.S. Patent No. 5,074,489. System 10 maintains a connection to an external communications network 40, which may include the standard telephone  
5 network, a video network, a fiber optic network, a computer data network and/or other types of communications networks. A ground station functions in maintaining the link between system 10 and external communications network 40. A ground link controller located on platform 12 controls communications between platform 12 and the ground station.  
10 A satellite link controller located on platform 12 controls communications between platform 12 and one or more satellites 46.

As previously described, conventional cellular technology works by dividing a geographical area to be covered into small sized cells. Within each cell is placed a base station transmitter and receiver. Both cellular  
15 phone transmitters and base station transmitters transmit at a reduced power level suitable for the particular cell size. This scheme allows the available frequency spectrum to be reused by distant cells. A processor controls the setup and tearing down of each call made through subscriber cellular equipment.

20 Instead of having a multitude of land based transmitters and receivers, spread out over a large geographic area, system 10 joins them together into one central location. MBA antenna 14, when connected to MBA RF antenna circuitry 24, is capable of generating many independent antenna radiation beams 20 simultaneously. MBA RF Antenna circuitry  
25 24 is an RF beam forming network, typically including a Rotman lens or a Butler RF matrix, and an RF switching matrix. RF antenna circuitry 24 is capable of simultaneously generating all beams 20 of MBA antenna 14. The aperture distributions across all array elements 16 for all beams are superimposed on each other, making use of the same physical aperture  
30 which is common to all beams 20. Each beam 20 is assigned a

transmit/receive port in RF antenna circuitry 24. Each transmit/receive port is connected to a corresponding port of MBA control circuitry 30. MBA control circuitry 30 controls MBA antenna circuitry 24 by channeling signals to and from transmit/receive ports of MBA antenna circuitry 24. Each beam 20 covers a single cell 22. Thus, each beam replaces one terrestrial base station. RF antenna circuitry 24 with many beams enables MBA antenna 14 to cover an area with many cells. In addition, coverage can be expanded by joining multiple platforms 12 together. Each platform 12 is able to communicate with other platforms, 10 satellites and ground stations, forming a network.

In a preferred embodiment, shown in Figure 1, airborne cellular communications processor 26 is located on high altitude platform 12, preferably up to 150 kilometers high. Ground station 42 communicates with a ground link controller 56 located on high altitude platform 12 via 15 a suitable communications link such as RF, optical, microwave, etc. In addition, an optional satellite link controller 54 communicates with one or more satellites 46. Airborne cellular communications processor 26 controls the establishment and breakdown of calls. Airborne processor 26 communicates with ground station 42, through ground link controller 56. 20 Ground station 42 maintains communication links with external communications network 40. External communications network 40 may include the standard telephone network or other types of networks such as, video, fiber and/or data.

Similarly to maintaining communication links with satellites, high 25 altitude platform may include an auxiliary radio link for communicating with planes, ships or boats. Alternatively, MBA antenna 14 may be used to communicate with planes, ships or boats. The auxiliary radio link would be coupled to communications processor 26.

In a preferred embodiment, shown in Figure 2, cellular 30 communications processor 48 is ground based, communicating with

airborne cellular communications processor 58 through ground link controller 52. Optional satellite link controller 50 maintains communications with one or more satellites 46.

The laws of diffraction can be utilized to estimate the number of cells that can be serviced by MBA antenna 14. The following definitions apply:

$N$  = Number of cells

$D$  = Cell diameter

$d$  = Antenna array diameter

10  $h$  = Platform height

$F$  = Factor  $< 1$

$\lambda$  = Radio wavelength

$\Delta\theta$  = Angular extent of the entire service area (including  $N$  cells)

from the high altitude platform

15  $D = F\lambda h/d$

$N = (\Delta\theta d/F\lambda)^2$

As an example, assume  $\lambda = 15$  cm (for a frequency of 2 GHz),  $d = 5$  m,  $F = 1$  and  $\Delta\theta = 1$  rad (considering viewing angles smaller than  $30^\circ$  relative to the vertical direction on all cells). The number of cells,  $N$ , is  
20 approximately 1,000 (i.e. a grid of cells approximately  $32 \times 32$ ).

Platform height can also be estimated given the cell diameter. The platform height is primarily limited by the cell diameter and antenna array size, as shown in the following relationship:

$h = Dd/(F\lambda)$

25 Lower heights or larger antenna arrays will be required for smaller cell sizes. If high altitude platform 12 is at a height  $h = 20$  km, cell size 22 dimension  $D$  is calculated to be 600 m.

The example above is realistic for the following reasons. Generally, global winds are at a minimum between 17 and 22 km high,  
30 making it easier to maintain the position and orientation of high altitude

platform 12. The density of air at this altitude is low but still high enough to support a number of practical platforms 12 enumerated previously. In addition, the distance of 20 km is close enough to the earth, making it possible to energize the platform by power transmission or other means.

5 As cell size is reduced, the uniformity of transmission/reception levels inside cells 22 and the low inter-cell interference cause the general performance of system 10 to remain high. This is in direct contrast to the negative effects of reduced cell size associated with conventional cellular technology. Note that because of practical limitations on the size of  
10 antenna array 14, platforms that are located at heights much larger than that of the example will generate cells that are much larger than 600 meters and will not match the increasing need for lower cell sizes.

In a preferred embodiment, cellular communications system 10 is deployed together with specialized personal communication devices (i.e.  
15 personal cellular telephones or computer or video devices) distributed to subscribers. The high altitude platform 12 is positioned approximately vertical (i.e. 45° to 90° off the horizon) relative to most cells 22. MBA antenna 14 transmits and receives using circularly polarized radiation. The personal communication devices are equipped with an upwards looking  
20 antenna which can receive circularly polarized radiation and an optional sideways looking antenna which can receive linear polarization. The ability to receive linearly polarized radiation, in addition to circularly polarized radiation, allows the personal communications devices to also be used with conventional ground base stations. The feature of an upwards  
25 looking antenna made available to subscribers of the high altitude platform cellular service allows them to be used with satellite global communications systems, such as Motorola's Iridium system or Teledesic's Global Wireless Broadband Network, thereby enhancing the services available to subscribers with the same radio communication device they  
30 already own.

In another embodiment, the number of available calls or channels can be doubled by simultaneously utilizing both clockwise and counterclockwise circular polarization. Half the personal communication devices would be outfitted with a clockwise circularly polarized antenna and the other half with a counter clockwise circularly polarized antenna. Signals having clockwise circular polarization, for example, cannot be received by phones having counter clockwise circularly polarized antennas, and vice versa.

Another application of the system 10 is as an add-on to a global satellite system. Typically, global satellite systems have very large cells in sparsely populated areas. However, they utilize personal communication devices having upwards looking antennas. Thus, high altitude platform 12, positioned at a relatively low altitude compared to global satellite systems, can use the same phones already owned by subscribers, such as of low earth orbiting satellite systems, to provide higher resolution cell coverage in specifically chosen high traffic areas.

As stated previously, current cellular communications services cannot provide wideband services, such as video communication (e.g., traffic control of road junctions, picturephone, video on demand, etc.), computer communication, multimedia services, etc. Such wide bandwidth services would consume the available spectrum unless very small cells with high reusability of the spectrum were employed. Cellular communications system 10 can provide such wideband services due to its ability to provide small size cells having sharp beam cutoffs between cells. An advantage of this feature is that system 10 can be employed in delivering wideband communications services. These services may be integrated in present state of the art communications networks (e.g., the Internet), making it possible to provide a large number of subscribers with enhanced quality and high speed transmission of pictures, real time video and large computer data files. Such services can also be provided through

other video and multimedia vendors, including cable TV, or video networks (which can provide personal movie order transmissions), picturephone networks, etc. In addition, it may be possible that the orthogonality between the polarizations of the vertically transmitting  
5 system and the standard horizontally transmitting system, may allow the reuse of the entire frequency bandwidth allocated for ground based services (including the telephone service bands). In addition, system 10 can be employed to respond quickly to the demand for new service areas.

Another application of cellular communications system 10 is as a  
10 complement to conventional existing ground based cellular networks. Ground based cellular communications systems can benefit from the flexible cell definition of system 10. Service in congested areas is improved by the ability to better define cell boundaries and to create smaller cells. In addition, new service areas can quickly be covered by  
15 system 10, on a temporary basis, until permanent base station equipment is installed. System 10 can also provide service to cells in which it would be difficult to locate a base station because of real estate problems or because of objections by local residents. Ground base stations that develop problems and cease to operate can be taken offline and temporarily  
20 replaced by system 10 until fixed and placed back in service.

In applications where system 10 complements conventional ground base stations, MBA antenna 14 must transmit and receive vertically polarized radiation in an almost horizontal direction. This makes it necessary to position floating platform 12 at some distance from the  
25 service area (i.e. less than  $45^\circ$  above the horizon) and to cause antenna array 14 transmit and receive nearly vertically polarized radiation. This allows system 10 to communicate with conventional personal communications devices. This will, however, reduce the number of available cells that can be serviced by system 10. Alternatively, the  
30 personal communications devices may be equipped with both horizontal

and vertical looking antennas and platform 12 may still be placed approximately above the service area.

While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, 5 modifications and other applications of the invention may be made.

## WHAT IS CLAIMED IS:

1. A high altitude platform cellular communications system comprising:

a cellular communications processor for controlling a plurality of wireless radio communication links between a plurality of cellular communication devices and the system;

multi-beam array antenna control circuitry coupled to said cellular communications processor, said multi-beam array antenna control circuitry for controlling radio frequency transmission from and reception to the high altitude cellular communications system;

multi-beam array circuitry coupled to said multi-beam array antenna control circuitry, said multi-beam array circuitry for simultaneously generating a plurality of transmission signals and for simultaneously receiving a plurality of reception signals;

a multi-beam array antenna coupled to said multi-beam array circuitry, said multi-beam array antenna for simultaneously generating a plurality of independent beams for transmission and reception of radio signals to and from previously assigned terrestrial cells; and

a high altitude platform for supporting the high altitude cellular communications system at a predetermined altitude, said high altitude platform for approximately maintaining the position of the high altitude cellular communications system at said predetermined altitude and horizontal position.



2. The cellular communications system of claim 1, wherein said transmission and reception signals include circularly polarized radiation broadcast to and from said cellular communication devices in a vertical direction.

3. The cellular communications system of claim 1, wherein said transmission and reception signals include both clockwise and counterclockwise circularly polarized radiation broadcast to and from said cellular communication devices in a vertical direction.

4. The cellular communications system of claim 1, wherein said transmission and reception signals include linearly polarized radiation broadcast to and from conventional cellular communication devices and said cellular communication devices in a nearly horizontal direction.

5. The cellular communications system of claim 1, wherein said cellular communication devices receive and transmit clockwise circularly polarized radiation broadcast to and from said multi-beam array antenna in a vertical direction.

6. The cellular communications system of claim 1, wherein said cellular communication devices receive and transmit counterclockwise circularly polarized radiation broadcast in a vertical direction.

7. The cellular communications system of claim 1, wherein said cellular communication devices receive and transmit linearly polarized radiation broadcast in a nearly horizontal direction.

8. The cellular communications system of claim 1, wherein said cellular communications devices receive and transmit circularly polarized radiation and linearly polarized radiation.

9. The cellular communications system of claim 1, wherein said high altitude platform maintains an altitude range up to 150 kilometers.

10. The cellular communications system of claim 1, wherein said high altitude platform includes a drone.

11. The cellular communications system of claim 1, wherein said high altitude platform includes an aerostat.

12. The cellular communications system of claim 1, wherein said high altitude platform includes an unmanned airborne vehicle.

13. The cellular communications system of claim 1, wherein said cellular communications processor includes an airborne cellular communications processor located on said high altitude platform.

14. The cellular communications system of claim 13, further comprising a ground station for maintaining communications with an external communications network, said ground station communicating with said airborne cellular communication processor through a ground link controller.

15. The cellular communications system of claim 1, wherein said cellular communications processor includes a ground portion and an airborne portion located on said high altitude platform, said ground portion communicating with said airborne portion through a ground link controller.

16. The cellular communications system of claim 15, further comprising a ground station for maintaining communications with an external communications network.

17. The cellular communications system of claim 1, further comprising a satellite link controller for communicating with one or more satellites.

18. The cellular communications system of claim 1, further comprising communications links with airplanes, ships and boats utilizing said MBA array antenna.

19. The cellular communications system of claim 1, further comprising an auxiliary radio link for providing communications with airplanes, ships and boats.

1/2

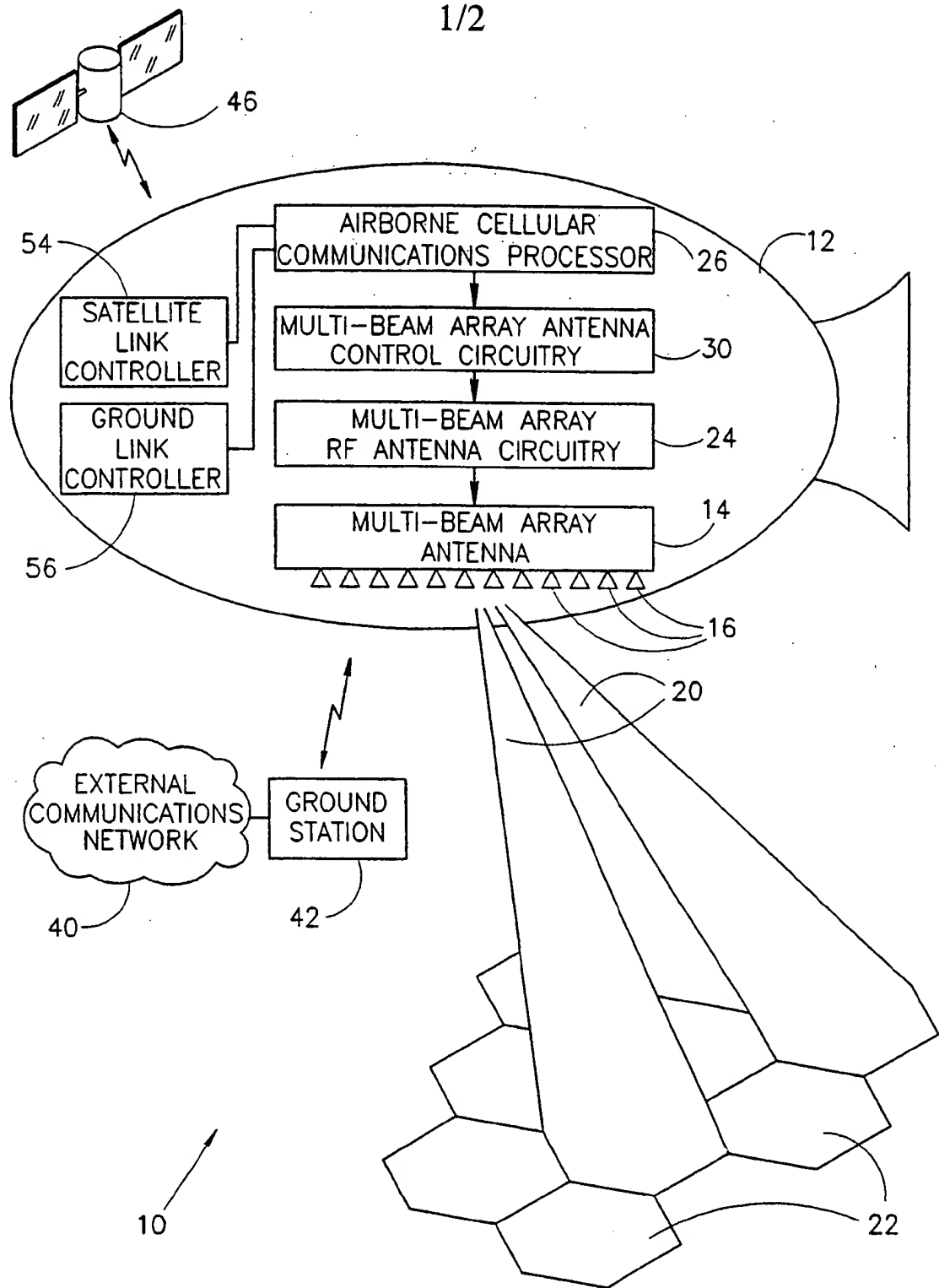


FIG.1

2/2

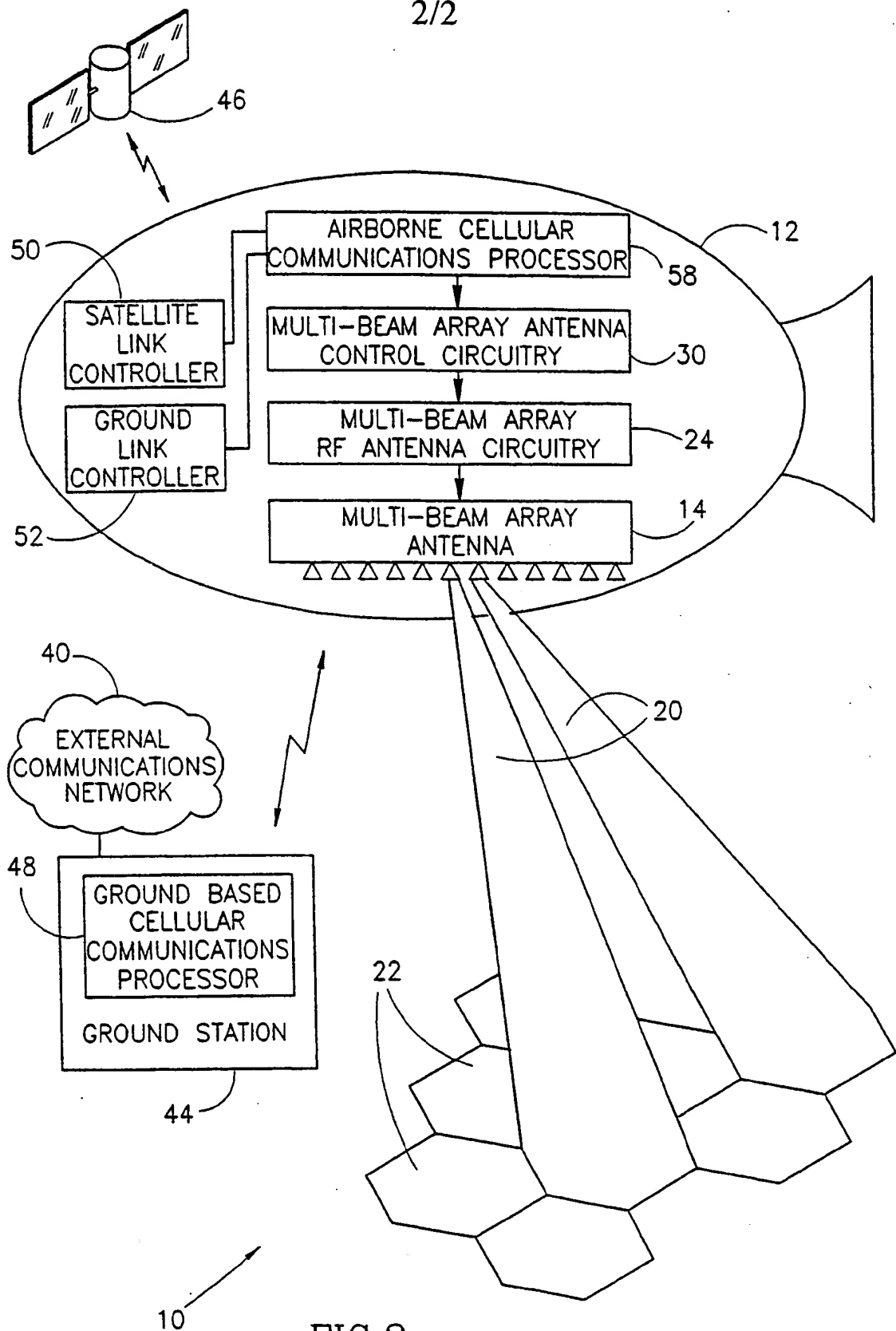


FIG.2

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<p>(21) International Application Number: <b>PCT/IL96/00074</b></p> <p>(22) International Filing Date: 7 August 1996 (07.08.96)</p> <p>(30) Priority Data: 08/514,050 11 August 1995 (11.08.95) US</p> <p>(71) Applicant (for all designated States except US): <b>RAMOT UNIVERSITY AUTHORITY FOR APPLIED RESEARCH &amp; INDUSTRIAL DEVELOPMENT LTD. (IL/IL); P.O. Box 39296, 61392 Tel Aviv (IL).</b></p> <p>(72) Inventors; and</p> <p>(75) Inventors/Applicants (for US only): <b>GOVER, Avi (IL/IL); 19 Hamachtenet Street, 47203 Ramat Hasharon (IL). KASTNER, Raphael (IL/IL); 9 Zamir Street, 45100 Hod Hasharon (IL).</b></p> <p>(74) Agent: <b>FRIEDMAN, Mark, M.; Samueloff Building, 7 Haomanim Street, 67897 Tel Aviv (IL).</b></p>		<p>(81) Designated States: <b>AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</b></p> <p><b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p> <p>(88) Date of publication of the international search report: 22 May 1997 (22.05.97)</p>

FIG. 1 is a block diagram of a multi-beam array antenna system. The system includes an **AIRBORNE CELLULAR COMMUNICATIONS PROCESSOR** (26) connected to **MULTI-BEAM ARRAY ANTENNA CONTROL CIRCUITRY** (30). This control circuitry is connected to **MULTI-BEAM ARRAY RF ANTENNA CIRCUITRY** (24), which in turn is connected to a **MULTI-BEAM ARRAY ANTENNA** (14). The antenna is represented by a series of small triangles (16). A **GROUND STATION** (42) is connected to the antenna via a signal path (20). The ground station is also connected to an **EXTERNAL COMMUNICATIONS NETWORK** (40). A **SATELLITE LINK CONTROLLER** (54) and a **GROUND LINK CONTROLLER** (56) are shown, with the satellite link controller connected to the ground link controller via a signal path (46). The entire system is enclosed in a dashed boundary (10).

A high altitude cellular communications system platform utilizing a multi-beam array antenna (12). The antenna and associated circuitry are mounted on a platform positioned up to 150 kilometers high. A cellular communications processor controls wireless communications links or calls with subscribers personal communications devices. Vertical broadcasting provides sharp antenna radiation pattern boundaries between cells allowing for both high inter-cell resolution and small cell size. In an alternative embodiment, the cellular processor is located on the ground and communicates with the high altitude platform. The system can operate independently or in conjunction with ground based cellular systems and low earth orbit satellite systems using common personal communications devices.

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/IL96/00074

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04Q 7/30  
US CL :455/33.1

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 455/33.1, 11.1, 12.1,13.1,13.2,13.3,13.4,33.2,33.3,33.4; 379/58,59; 342/352,354

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

search terms: high altitude platform, Ita, lighter than air, cellular, communications.

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, 5,408,237 A (PATTERSON et al) 18 April 1995, see fig 11, col 4, lines 40-62, col 14, lines 28-34.	1-19
X	ONDA, M. et al, A Stratospheric Unmanned Powered Lighter Than Air Platform, ICAS Vol 1, pp198-208, Sept 1992, especially page 199 col 1-2, fig 4.	1-19
Y,P	US 5,552,920 A (GLYNN) 03 September 1996, fig 7C col 10, lines 9-18.	2-8
A	GB 2,082,995 A (MCNULTY) 17 March 1982, figure col 1, lines 3-49	1-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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* O* document referring to an oral disclosure, use, exhibition or other means	
* P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

11 MARCH 1997

Date of mailing of the international search report

14 APR 1997

Name and mailing address of the ISA/US  
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